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Effect of Marble Powder and Steel Fibers on Hardened Properties of Concrete

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Abstract: *In contemporary concrete industry, there is a need of sustainable improvement because of large demand of cement, so concrete industry should be utilized the industrial and farming waste components. After scrutinized past years report, cement produce large amount of carbon dioxide gas released in environment during the production of cement that is consequences for global warming and greenhouse effect, it is not denying that cement is the main ingredient in the production of concrete. For reducing environmental problems and cement demand, we were utilized Waste marble powder and steel fibers in this study and analyzed the strength of concrete. This investigation carried out by destructive and Non Destructive method to evaluate the strength of concretefrom test, 36 cubes were casted of size 150mm x150mm x 150mm, for testing after 7 and 28 days. Both, split tensile strength and Flexural strength were examine by after 28 days, 18 cylinders were casted of 150mm x 300mm and 18 beams of size 500mm x 100mm x 100mm. For experiment six concrete mixes was prepared with M20 grade of concrete used. OPC was partially substitute by marble powder at 10% and 15 % by weight of binder. With addition of steel fibers using length of 30mm, aspect ratio 60 and volume fraction 0.5%, 0.75% and 1% . The water/cement (w/c) proportion was varying from 0.43-0.45 in M.P and 0.5 in steel fibers reinforced concrete. Then compare properties of conventional concrete mix (cubes, cylinders, and beams) with M.P (10% and 15%) and SFRC (0.5%-1%) +M.P (10%).*

Keywords: Destructive test, Marble Powder, Nondestructive test, Steel fiber and Steel fiber reinforced concrete

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I. INTRODUCTION

1. Fiber reinforced concrete

Fibers can be define as a small unit of strengthening material like reinforcement, having certain dimensional characteristics. Important parameter define a fiber is its Aspect ratio. "Aspect ratio" is the ratio of fiber length divided by an equivalent diameter of the fiber. Type of fiber influenced the properties of fiber reinforced concrete.Fibers are secondary reinforcement unit in concrete and acts as crack arrester. Fibers prevent propagation of cracks starting from internal flaws can result in enhancements in static and dynamic properties of the matrix. Fibers are generally Discontinuous, randomly distributed throughout the cement matrices.

2. Steel fiber

Search of steel fiber reinforced concrete introduced to expand its importance in the 1970s, and from those days different kinds of steel fibers have been developed. Aspect ratio plays vital role in describing the parameter of fibers. It may vary from 30-150.Steel fibers are available in different diameter may vary from 0.25-0.75 and small length vary from 30-150mm. The tensile strength of fibers ranges in between 300 and 2400MPa.Volume fraction of fiber may vary from 0.5% to 2% by weight of binder. As fiber content increased it indicates that workability of concrete reduced.

3. Marble powder

Marble is a crystalline, compact variety obtained from metamorphic limestone, consisting prime minerals of calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) or a combination of these minerals. Calcium compound (calcareous) is a base mineral for marble. Marble powder can be utilize for construction purpose after cutting and polish. Widespread deposits are located in Italy, India, Pakistan, Greece, Brazil, China, Afghanistan, Turkey,Turkey, Great Britain, and in the United States.Marble stone industry form both solid and stone slurry and as per past study solid waste produce more in marble stone industry. All over the world marble produce 168million tons. Out of which 40% of waste formed, that is around 68 million tons. (Bokka NVDS Parkash (2016)). A huge amount of powder is produced during the process of cutting. As a result mass of marble waste has reached as high as millions of tons so to reduce this discarded waste, used it in this experiment.

II. RESEARCH OBJECTIVE

1. Compare the compressive strength with destructive and non-destructive test at different percentages of marble powder (10% and 15%) and M.P (10%) with different percentages of steel fibers fraction (0.5%, 0.75%, and 1%).
2. To determine the splitting tensile strength at different percentages of marble powder (10% and 15%) and M.P (10%) with different percentages of steel fibers fraction (0.5%, 0.75%, and 1%).
3. Evaluate the flexural strength at different percentages of marble powder (10% and 15%) and M.P (10%) with different percentages of steel fibers fraction (0.5%, 0.75%, and 1%).

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III. PROBLEM FORMULATION

A conventional concrete mix was used in this examination for comparing strength with other concrete nix by using MP and steel fibers. Six concrete mix samples having different percentages of M.P with different volume of steel fiber fraction were used in this investigation. The mixes were designated as given below in table 1.

Table 1 concrete mix with Marble Powder and steel fibers

Mix Name	OPC (%)	Marble Powder (%)	Steel Fiber (%)
CC	100	0	0
M.P	90	10	0
M.P +$SFRC_{0.5}$	90	10	0.5
M.P+$SFRC_{0.75}$	90	10	0.75
M.P+ $SFRC_1$	90	10	1
M.P	85	15	0

IV. EXPERIMENTAL INVESTIGATION

To obtain the objective of this experiment is divided into following stages:

1. Physicalproperties of material used
2. Mix Design
3. Casting and curing of tests specimens
4. Investigating the hardened properties of concrete mix.

Physical and chemical properties of material used the materials used for making concrete mix were cement, fine aggregate, coarse aggregates, water, sand, marble powder and fibers. These materials were having the following characteristics as mentioned below.

A. . Cement

Characteristic Properties	Observed Value	Codal Requirements
Fineness (m^2/kg)	300	225 Minimum
Standard consistency (%)	32	30-35
Initial Setting time (minutes)	62	30 Minimum
Final setting time (minutes)	270	600 Maximum
Specific gravity	3.15	3.10-3.15
Compressive strength (MPa) 7-days	46.5	43 Minimum
Compressive strength (MPa)28	57.8	53 Minimum

Table 2 Physical Properties of Cement

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B. Fine aggregate

Physical properties of fine aggregates Confirming zone II as per IS383:1970, Grading zone= Zone II, Fineness Modulus=2.63 and Specific gravity=2.65

C. Coarse aggregate

The average size of aggregate lies in between 10mm to 20mm.Coarse aggregates specific gravity= 2.71

Fineness modulus =7.14

Specific gravity = 2.71

= $\frac{\text{percentage}}{}$ equation (1)

= = *7.14*

Table 3Physical Properties of coarse Aggregates

IS Sieve (mm)	Weight retained on sieves(gm)	%age Weight re-tained	Cumulative %age weight retained on sieves(gm)	%age cum. Weight retained on sieves
40mm	00	0	0	100
20mm	1167	23.34	23.34	76.66
10mm	3379	67.58	90.92	9.08
4.75mm	454	9.08	100	0
Pan	0	0	0	0
Total			214.26	

D. Water

As per IS: 456-2000 consumable water is considered satisfactory for mixing and curing purposes of concrete. Hence consumable water was utilized to preparing of all concrete specimens entire experimental work.

E. Steel fibers

Table 4 properties of steel fibers

Properties	Value
Diameter(d)	0.5mm
Length(L)	30mm
Aspect Ratio(L/d)	60
Density(kg/m^3)	7850
Tensile Strength N/mm^2	532
Young's modulus(GPa)	210
Shape	Hooked end

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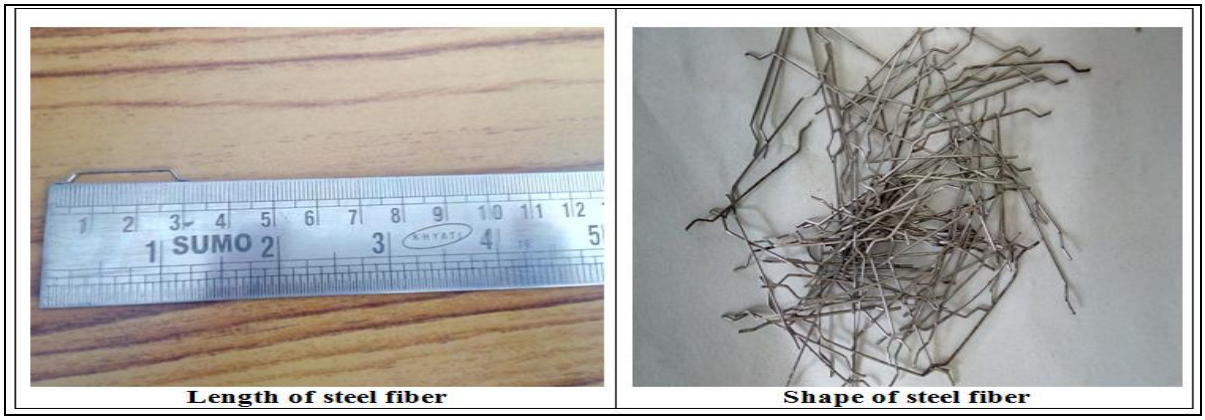

Figure 1 steel fibers

F. Marble Powder

Marble powder is utilize in place of cement. It was grinded to form fine powder like cement binder material.

Figure 2 marble powder

G. Casting Moulds

The moulds should be free from dust, clean with a brush and lubricated before casting of the beams.

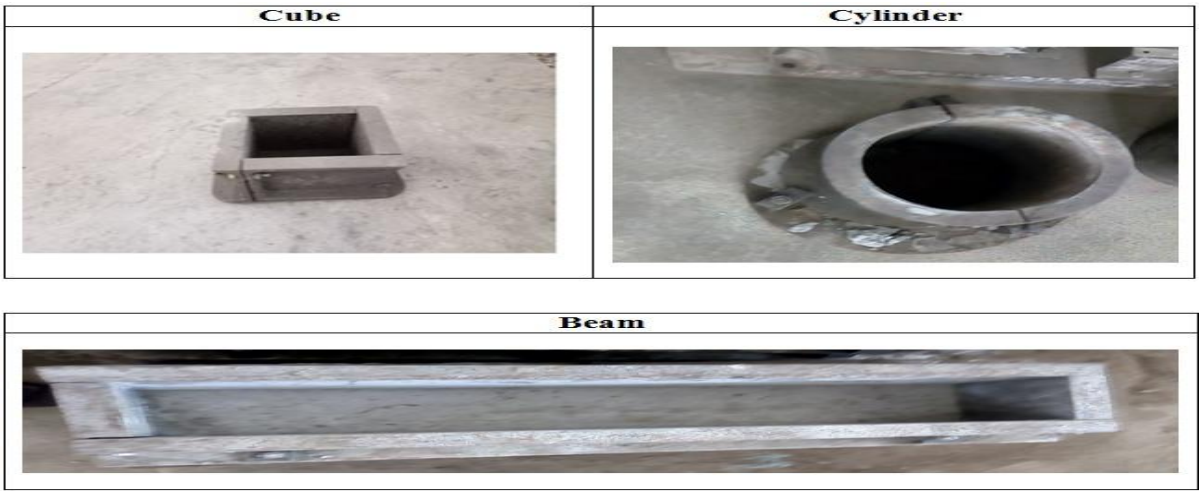

Figure 3 moulds of cube,cylinder and beam

H. Concrete Mix Proportion

M20 grade of concrete for conventional mix was use for experiment. The mix proportion for M20 is given in the

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Table 5 Mix Proportion of M20 grade

Ingredients	Conventional concrete mix	10%MP	15%MP	0.5-1.5 SF.R.C
Cement	431.33 Kg/m^3	372 Kg/m^3	351.33 Kg/m^3	372 Kg/m^3
Fine Aggregate	687.781 Kg/m^3	700.87Kg/m^3	707.92	829.9 Kg/m^3
Coarse Aggregate	1146.33 Kg/m^3	1169.41Kg/m^3	1181.18 Kg/m^3	1037.39 Kg/m^3
Water-Cement Ratio	186 Kg/m^3	186 Kg/m^3	186 Kg/m^3	186 Kg/m^3
Marble powder	0	41.33 Kg/m^3	61.99 Kg/m^3	15%
Steel fibers	0			0.5-1.5%

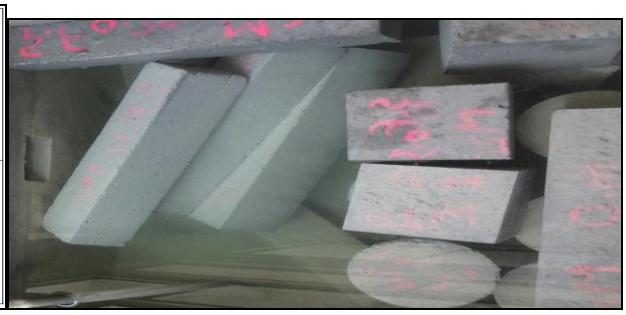

Figure 4 Pan Mixer used for mixing and moldfor casting.

Figure 5Specimen placed in temperature controlled curing

V. TESTS ON HARDENED CONCRETE

A. Destructive Test by Compression Testing machine

Samples were taken out after 7 and 28 days from curing tank. Specimens were put on a Compression Testing Machine (CTM) having 200 tones capacity (Figure 8). This test performed according to the code BIS: 516-1979.Non-destructive testing (NDT) is the method for examining, reviewing, or evaluating concrete mix, with-out damaging the serviceability part of the structure.

Figure 6Destructive Test

In this experimental investigation following test were performed for evaluating the compressive strength of cubes.

B. Nondestructive test by Schmidt / Rebound Hammer Test

This test investigated the hardness of the surface. The test was conducted as per IS 13311- part2: (1992). Evaluate the compressive strength of all concrete mixes after 7 and 28 days. Different percentage of M.P (10% and 15%) and 10% M.P +S.F (0.5-1%), Compressive strength test was conducted on cubes. variation in result due to replacement of cement with M.P.

Figure 7testing of cubes by rebound hammer

C. Nondestructive test by Ultrasonic Pulse Velocity Test

This test examined the sound velocity of concrete. According to code velocity above 4.5 km/s concrete quality grading excellent, in between 3.5-4.5 concrete grading good. These provisions are given in code.

Figure 8Ultrasonic Pulse Velocity Testing of Cubes

D. Splitting Tensile Strength Test

The test was conducted after 28 days curing of samples. Test was conducted as per BIS: 516-1979. The split tensile strength was determined by using the following formula.

Split tensile Strength (MPa) = 2P / ΠDL

Where P = Peak Splitting Load in KN, D= Diameter and L = Length of cylinder sample in mm.

Figure 9 Split Tensile Strength Testing of Cylinders for all concrete mixes at 28 days

E. Flexural Strength Test

The tests were performed on concrete beams length is 500 and breadth is 100 mm and height is 100mm. These tests were conducted on 100 kN UTM (Universal testing machine) .The complete load-deflection curve was recorded for each specimen using the data acquisition system of the machine. The test was conducted as per codal prevision BIS: 516-1979. This machine gave result in the form of curve load versus deflection for each beam in different graph, after that make one single graph in MS excel.

Figure 10Flexural Testing of Beams

VI. RESULTS AND DISCUSSION

A. Compressive strength test results

Evaluate the compressive strength of all concrete mixes after 7 and 28 days. At Different percentage of M.P (10% and 15%) and 10% M.P +S.F (0.5-1%), Compressive strength test was conducted on cubes. variation in result due to replacement of cement with M.P. The results are shown in table 12. It is depicted in table that after

7 days, by using compression testing machine the strength is 18.86 and after 28 it is 27.23.with destructive method result of strength is higher than compression testing machine. Table 6comparison of result by destructive and nondestructive method.

Set Type	Compressive Strength (MPa)@7 days	Compressive Strength (MPa)@28days	Rebound Compressive Strength (MPa)@7days	Rebound Compressive Strength (MPa)@28days	UPV compressive strength@7 days(MPa)	UPV Compressive Strength @28 days (MPa)
CC	18.86	27.23	26.5	32	27.74	31.78
M.P (10%)	19.97	29.04	28.5	33.5	29.53	33.37
M.P (15%)	17.72	26.13	25	30	26.72	30.27
M.P(10%)+ $SFRC_{0.5}$	20.49	31.49	30	37	30.82	34.57
M.P(10%)+ $SFRC_{0.75}$	22.20	33.21	32	39	32.25	36.57
M.P(10%)+ $SFRC_{1}$	24.59	35.59	34	42	35.82	41.3

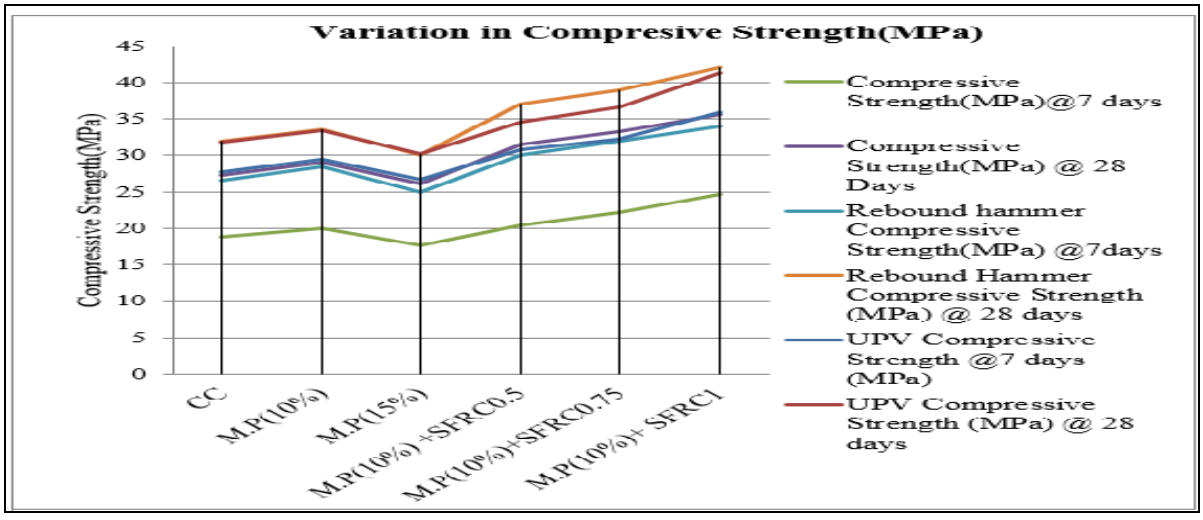

Figure 11 Graph of variation in compressive strength

B. Split tensile strength

The split tensile strength for M20 concrete mix without marble powder and steel fibers is 2.91N/mm² at 28 days. The average percentage change in split tensile strength is 12.02% at 10% replacement of cement by marble powder. With further increase in marble powder i.e. 15% show decrease in strength by 9.62%. Further inclusion of M.P (10%) and S.F (0.5%-1%) show increase in strength.

Table 7results of split tensile strength

Sr. No.	Set Type	Marble powder (%)	Steel Fiber Volume Fraction (%)	Avg. Load (KN)	Split tensile Strength (MPa)
1	CC	0	0	206.01	2.91
2	M.P	10	0	230.535	3.26
3	M.P	15	0	225.48	3.19
4	SFRC0.5	10	0.5	245.25	3.46
5	SFRC0.75	10	0.75	264.87	3.74
6	SFRC1	10	1	271.34	3.83

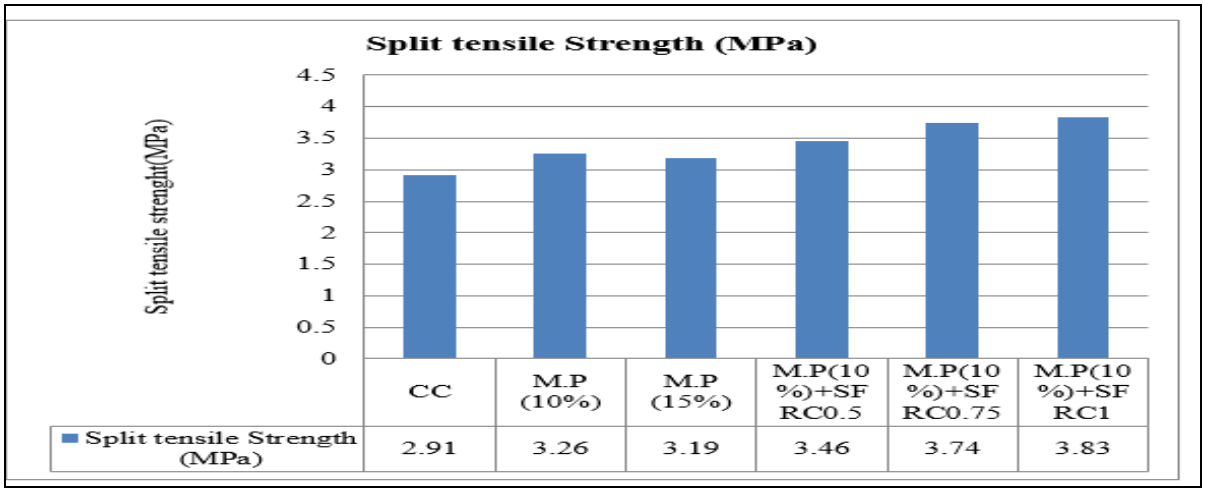

Figure 12 results of split tensile strength

C. Flexural strength test

The flexural strength for M20 concrete mix without marble powder and steel fibers is 11.55N/mm² at 28 days. The average percentage change in flexural strength is 9.09% at 10% replacement of cement by marble powder. With further increase in marble powder i.e. 15% show decrease in strength by 6.49%. Inclusion of M.P (10%) and S.F (0.5%-1%) show increase in flexural strength. Results shown in below table 8.

Set Type	Marble powder (%)	Steel Fiber Volume Fraction (%)	Avg. Load (KN)	Flexural Strength (MPa)	Percentage increase in Flexural Strength w.r.t. to Control Beams
CB	0	0	7.7	11.55	-
M.P	10	0	8.4	12.6	9.09
M.P	15	0	8.2	12.3	6.49
SFRC0.5	10	0.5	8.7	13.05	12.98
SFRC0.75	10	0.75	9	13.5	16.88
SFRC1	10	1	10.1	15.15	31.16

The following was the observation of UTM graphs (Load vs Deflection) which was observed during the investigating of beams for flexural strength.

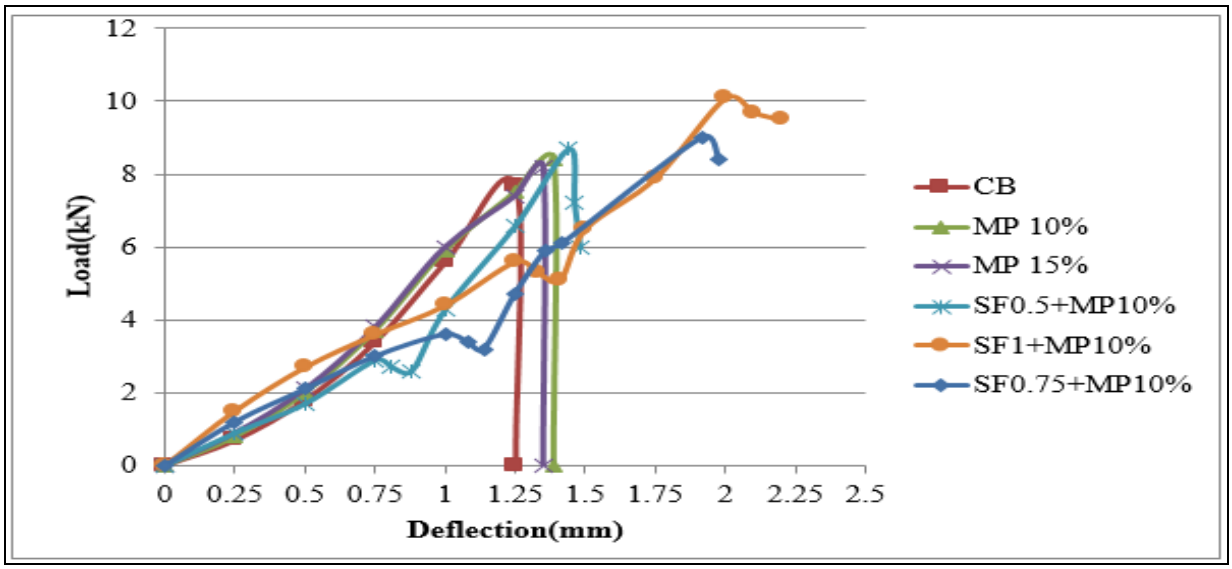

Figure 13 load versus deflection graph

VII. CONCLUSIONS

The addition of M.P and steel fibers in concrete mix as compared to control mix where as

i. The compressive strength was found to be maximum with the replacement of 10% of cement with marble powder. Therefore all the studies have been carried out with the replacement of cement with marble powder (10%).

ii. The compressive strength of concrete with 10% replacement of marble powder and addition of steel fibre from 0.5%-1% was found to increase by 30.38% with destructive test, 28.3% with non-destructive test (rebound hammer) and 29.11% non-destructive test (ultrasonic pulse velocity) at 7 days.

iii. The compressive strength of concrete with 10% replacement of marble powder and addition of steel fibre from 0.5%-1% was found to increase by 30.70% with destructive test at 28 days, 31.25% with non-destructive test (rebound hammer) and 29.96% non-destructive test (ultrasonic pulse velocity) at 28 days.

iv. The incorporation of marble powder in concrete mix was found to increase in splitting tensile strength at 10% replacement and addition of steel fibres from 0.5-1% into concrete mix increases the splitting tensile strength by 31.61%.

v. The flexural strength increases up to 10% marble powder replacement of cement, there after decreased in strength.

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